U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-281 888

Starvation Reservoir Duchesne County, Utah

National Eutrophication Survey, Corvallis, Oreg.

Prepared for

Corvallis Environmental Research Lab., Oreg.

Nov 77

PB 281 888

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY
WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

G.P.O. 699-440

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO. PB281888
4. TITLE AND SUBTITLE Report on Starvation Reservoir, Duchesne County, Utah		5. REPORT DATE Prepared November 1977 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper #858
9. PERFORMING ORGANIZATION NAME AND ADDRESS Pacific Northwest Environmental Research Laboratory U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 1BA029 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1975 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT
Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading	National Eutrophication Survey Lake Survey	05B 05C

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release Unlimited	Unclassified	34
	20. SECURITY CLASS *(This page)*	22. PRICE A03-A01

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

REPORT
ON
STARVATION RESERVOIR
DUCHESNE COUNTY
UTAH
EPA REGION VIII
WORKING PAPER No. 858

WITH THE COOPERATION OF THE
UTAH STATE DIVISION OF HEALTH
AND THE
UTAH NATIONAL GUARD
NOVEMBER, 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Utah Department of Social Services and the Utah Department of Natural Resources for professional involvement, to the Utah National Guard for conducting the tributary sampling phase of the Survey, and to those Utah wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staffs of the Bureau of Water Quality of the Division of Health and the Division of Wildlife Resources provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

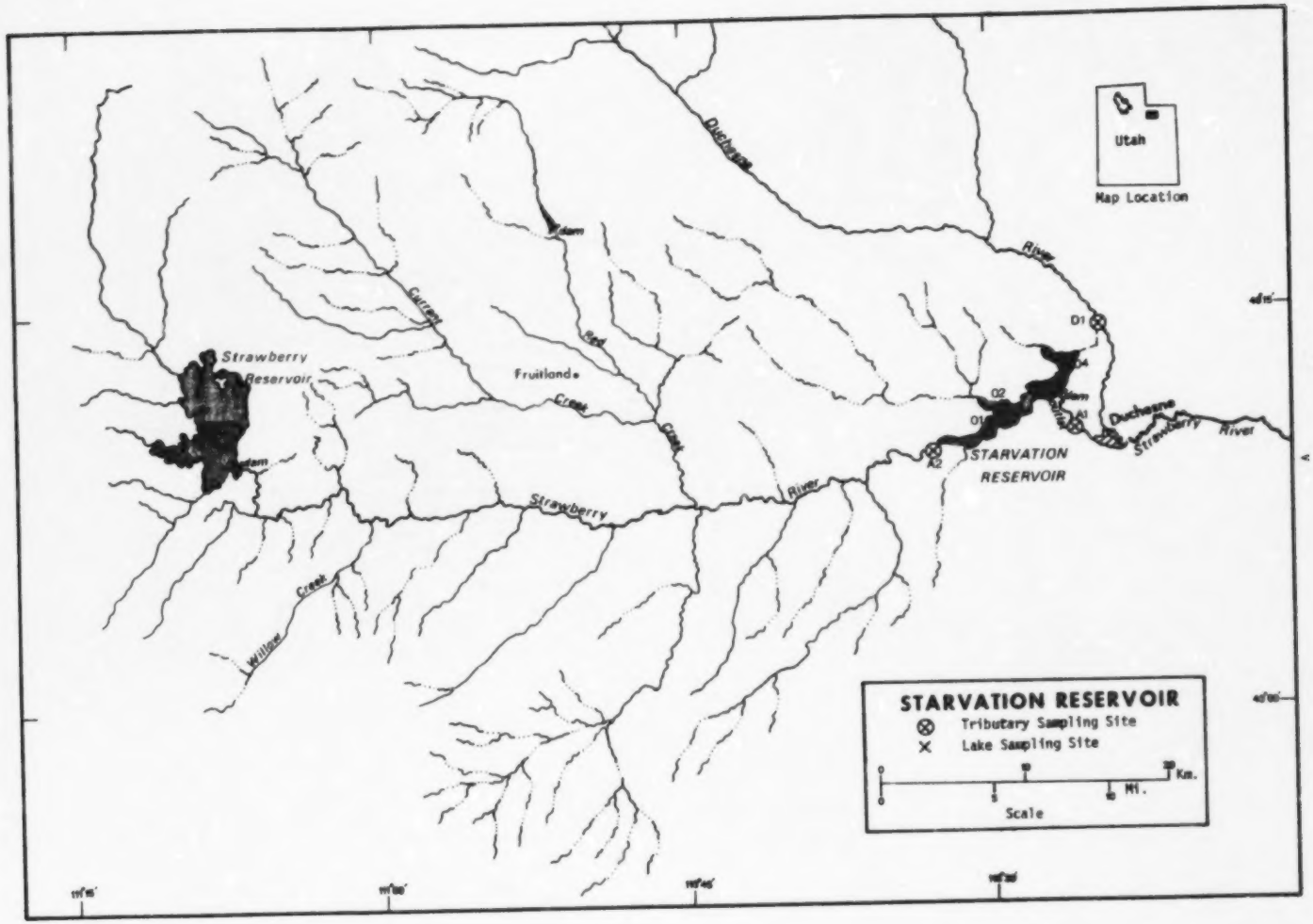
Major General Maurice L. Watts, the Adjutant General of Utah, and Project Officer Lt. Colonel T. Ray Kingston, who directed the volunteer efforts of the Utah National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES AND RESERVOIRS

STATE OF UTAH

NAME	COUNTY
Bear	Rich, UT; Bear Lake, ID
Deer Creek	Wasatch
Echo	Summit
Fish	Sevier
Flaming Gorge	Daggett, UT; Sweetwater, WY
Huntington	Emery
Joes Valley	Emery
Lower Bowns	Garfield
Lynn	Box Elder
Minersville	Beaver
Moon	Duchesne
Navajo	Kane
Newcastle	Iron
Otter Creek	Piute
Panguich	Garfield
Pelican	Uintah
Pineview	Weber
Piute	Piute
Porcupine	Cache
Powell	Garfield, Kane, San Juan, UT; Coconino, AZ
Pruess	Millard
Sevier Bridge	Juab, Sanpete
Starvation	Duchesne
Steinaker	Uintah
Tropic	Garfield
Utah	Utah
Willard Bay	Box Elder


Utah
Map Location
Duchesne River
Strawberry Reservoir
Dam
Current Creek
Red Fruitland Creek
Strawberry River
Willow Creek
D1
D2
O1
O2
STARVATION RESERVOIR
Duchesne Strawberry River
STARVATION RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Km.
Mi.
Scale

STARVATION RESERVOIR

STORET NO. 4921

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Starvation Reservoir is mesotrophic. It ranked tenth in overall trophic quality when the 27 Utah lakes and reservoirs sampled in 1975 were compared using a combination of six parameters*. Seven of the water bodies had less and one had the same median total phosphorus, none had less and ten had the same median inorganic nitrogen, five had less and two had the same median dissolved orthophosphorus, ten had less chlorophyll a, and nine had greater mean Secchi disc transparency. Significant depression of dissolved oxygen with depth occurred at sampling station 1 in August and September and at stations 2 and 4 in August.

Survey limnologists did not observe surface concentrations of algae or aquatic macrophytes in the reservoir.

B. Rate Limiting Nutrient:

The results of the algal assay are not considered representative of conditions in the reservoir because of significant changes in nutrients in the samples from the time of collection to the beginning of the assays.

The reservoir data indicate nitrogen limitation all three sampling times.

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* See Appendix A.

C. Nutrient Controllability:

1. Point sources--No known wastewater treatment plants impacted Starvation Reservoir during the sampling year.

The sampling year phosphorus loading of 2.70 g/m^2 is four times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). During the sampling year, Starvation Reservoir was still filling and, at that time, apparently had not responded to the high loading. However, it is probable the trophic quality of the reservoir will deteriorate if the load measured during the sampling year is not reduced.

2. Non-point sources--Non-point sources, including direct precipitation, contributed all of the total phosphorus load to the reservoir during the sampling year. The Strawberry River added 82.5% of the total; the Duchesne River diversion, 5.3%; and the ungaged tributaries contributed an estimated 11.6%.

The phosphorus export rate of the Strawberry River was 10 kg/km^2 during the sampling year (see page 10).

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 11.17 kilometers^2.
2. Mean depth: 19.9 meters.
3. Maximum depth: 47.2 meters.
4. Volume: 200.812 x 10^6 m^3.
5. Mean hydraulic retention time: 1.8 years (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Strawberry River	2,382.8	4.110
Duchesne River (via Knight Diversion)	0.0	1.714
Minor tributaries & immediate drainage -	351.4	0.010
Totals	2,734.2	5.834

2. Outlet -

Strawberry River	2,745.4**	3.470**

C. Precipitation***:

1. Year of sampling: 18.1 centimeters.
2. Mean annual: 18.9 centimeters.

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† Table of metric equivalents--Appendix B.
†† Sudweeks, 1975.
* For limits of accuracy, see Working Paper No. 175, "... Survey Methods, 1973-1976".
** Includes area of reservoir; reservoir filling during sampling year.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Starvation Reservoir was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at four stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 18.3 meters at station 1, 22.9 meters at station 2, 5.8 meters at station 3, and 14.0 meters at station 4.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR STARVATION RESERVOIR
STORET CODE 4921

PARAMETER	1ST SAMPLING (5/13/75) 4 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/11/75) 4 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (9/24/75) 4 SITES RANGE	MEAN	MEDIAN
TEMP (C)	6.3 - 8.2	7.0	6.7	6.3 - 17.8	14.4	16.2	15.1 - 17.4	17.0	17.1
DISS OXY (MG/L)	9.0 - 10.4	9.6	9.6	1.8 - 8.0	5.7	7.4	2.8 - 9.2	6.8	7.2
CNDCTVY (MCROMO)	489. - 505.	499.	499.	575. - 640.	615.	620.	510. - 552.	524.	522.
PH (STAND UNITS)	8.6 - 8.6	8.6	8.6	8.2 - 9.1	8.8	8.8	8.2 - 8.6	8.6	8.6
TOT ALK (MG/L)	266. - 354.	303.	303.	191. - 306.	250.	260.	244. - 348.	302.	298.
TOT P (MG/L)	0.012 - 0.025	0.018	0.018	0.008 - 0.022	0.015	0.016	0.012 - 0.031	0.016	0.015
ORTHO P (MG/L)	0.003 - 0.013	0.007	0.006	0.002 - 0.013	0.004	0.003	0.003 - 0.009	0.005	0.004
NO2+NO3 (MG/L)	0.020 - 0.050	0.022	0.020	0.020 - 0.050	0.022	0.020	0.020 - 0.040	0.021	0.020
AMMONIA (MG/L)	0.020 - 0.040	0.031	0.030	0.020 - 0.080	0.029	0.020	0.020 - 0.020	0.020	0.020
KJEL N (MG/L)	0.200 - 0.500	0.350	0.400	0.200 - 0.500	0.347	0.300	0.200 - 0.300	0.224	0.200
INORG N (MG/L)	0.040 - 0.080	0.053	0.050	0.040 - 0.130	0.051	0.040	0.040 - 0.060	0.041	0.040
TOTAL N (MG/L)	0.220 - 0.530	0.372	0.420	0.220 - 0.550	0.369	0.320	0.220 - 0.340	0.245	0.220
CHLRPYL A (UG/L)	2.6 - 5.8	4.0	3.8	1.6 - 20.7	9.3	7.5	2.1 - 6.1	3.7	3.2
SECCHI (METERS)	1.2 - 2.9	2.2	2.3	3.0 - 5.2	4.1	4.1	0.9 - 2.7	1.8	1.7

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/13/75	1. Stephanodiscus sp.	1,179
	2. Fragilaria sp.	937
	3. Asterionella sp.	514
	4. Diatoma sp.	30
	Total	2,660
08/11/75	1. Oocystis sp.	165
	2. Chroomonas sp.	110
	3. Dinobryon sp.	82
	4. Cryptomonas sp.	55
	Total	412
09/24/75	1. Chroomonas sp.	125
	2. Cryptomonas sp.	94
	3. Stephanodiscus sp.	63
	4. Ankistrodesmus sp.	63
	5. Mallomonas sp.	31
	Total	376

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/13/75	1	5.8
	2	4.7
	3	3.0
	4	2.6
08/11/75	1	1.6
	2	4.5
	3	10.5
	4	20.7
09/24/75	1	6.1
	2	3.9
	3	2.6
	4	2.1

C. Limiting Nutrient Study:

The results of the algal assay are not considered representative of reservoir conditions because significant nutrient changes occurred in the samples from the time of collection to the beginning of the assays.

The reservoir data indicate nitrogen limitation; i.e., the mean inorganic nitrogen to orthophosphorus ratios were 8 to 1 in May, 13 to 1 in August, and 8 to 1 in September.

IV. NUTRIENT LOADINGS
(See appendix E for data)

For the determination of nutrient loadings, the Utah National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of May and June when two samples were collected. Sampling was begun in November, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Utah District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads, in $kg/km^2/year$, at station A-2 and multiplying by the ZZ area in km^2.

No known wastewater treatment plants impacted Starvation Reservoir during the sampling year.

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* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal - None

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Strawberry River	24,880	82.5
Duchesne River diversion	1,585	5.3
b. Minor tributaries & immediate drainage (non-point load) -	3,515	11.6
c. Known municipal STP's - None	-	-
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	195	0.6
Total	30,175	100.0

2. Outputs -

Reservoir outlet - Strawberry River	2,770

3. Net annual P accumulation - 27,405 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Strawberry River	212,550	55.9
Duchesne River diversion	124,425	32.7
b. Minor tributaries & immediate drainage (non-point load) -	31,275	8.2
c. Known municipal STP's - None	-	-
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	12,060	3.2
Total	380,310	100.0

2. Outputs -

Reservoir outlet - Strawberry River	87,865

3. Net annual N accumulation - 292,445 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Strawberry River	10	89

E. Mean Nutrient Concentrations in Duchesne River diversion:

Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
0.045	1.000

* See Working Paper No. 175.

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	2.70	2.45	34.0	26.2

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Starvation Reservoir:

"Dangerous" (eutrophic loading)	0.66
"Permissible" (oligotrophic loading)	0.33

V. LITERATURE REVIEWED

Sudweeks, Calvin K., 1975. Personal communication (reservoir morphometry). UT Bur. Env. Health, Salt Lake City.

Vollenweider, R. A., and P. J. Dillon, 1974. the application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
0408	LAKE POWELL	0.010	0.410	339.830	3.081	13.800	0.007
4901	BEAR LAKE	0.011	0.040	253.167	0.945	9.200	0.003
4902	LOWER BOWN'S RESERVOIR	0.031	0.040	336.000	5.567	9.400	0.006
4903	DEER CREEK RESERVOIR	0.038	0.215	430.333	9.078	14.800	0.006
4904	ECHO RESERVOIR	0.047	0.170	450.333	6.967	14.000	0.012
4905	LYNN RESERVOIR	0.121	0.200	417.667	39.600	10.400	0.052
4906	FISH LAKE	0.023	0.040	152.000	12.483	10.400	0.004
4907	HUNTINGTON NORTH RESERVO	0.013	0.040	392.000	1.900	7.800	0.005
4908	JOE'S VALLEY RESERVOIR	0.012	0.045	400.000	2.483	11.200	0.003
4909	MINERSVILLE RESERVOIR	0.192	0.060	445.000	33.583	8.600	0.107
4910	MOON LAKE	0.008	0.040	381.000	2.700	9.600	0.002
4911	NAVAJO LAKE	0.016	0.040	368.000	2.000	6.000	0.003
4912	NEWCASTLE RESERVOIR	0.051	0.040	428.667	12.467	13.600	0.009
4913	OTTER CREEK RESERVOIR	0.067	0.040	453.667	11.767	10.600	0.033
4914	PANGUITCH LAKE	0.071	0.040	426.500	45.950	14.200	0.010
4915	PELICAN LAKE	0.044	0.058	438.500	[illegible]350	8.400	0.004
4916	PINEVIEW RESERVOIR	0.028	0.300	435.083	5.692	14.600	0.006
4917	PIUTE RESERVOIR	0.047	0.150	482.625	25.329	11.600	0.007
4918	PORCUPINE RESERVOIR	0.025	0.110	440.000	7.860	12.400	0.011
4919	PRUESS RESERVOIR (GARRIS	0.057	0.140	491.000	4.533	8.800	0.008
4920	SEVIER BRIDGE RESERVOIR	0.026	0.355	449.778	18.222	12.400	0.008
4921	STARVATION RESERVOIR	0.016	0.040	394.583	5.675	13.200	0.004
4922	STEINAKER RESERVOIR	0.011	0.040	316.750	1.844	12.600	0.005
4923	TROPIC RESERVOIR	0.021	0.050	425.000	7.200	8.400	0.006
4924	UTAH LAKE	0.132	0.320	490.583	72.012	11.400	0.012
4925	WILLARD BAY RESERVOIR	0.044	0.060	457.182	7.567	11.000	0.009
5605	FLAMING GORGE RESERVOIR	0.011	0.690	285.636	2.500	10.400	0.003

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
0408	LAKE POWELL	96 (25)	4 (1)	81 (21)	73 (19)	15 (4)	42 (11)	311
4901	BEAR LAKE	90 (23)	87 (19)	96 (25)	100 (26)	77 (20)	90 (23)	540
4902	LOWER BOWN'S RESERVOIR	46 (12)	87 (19)	85 (22)	65 (17)	73 (19)	50 (13)	406
4903	DEER CREEK RESERVOIR	42 (11)	19 (5)	42 (11)	35 (9)	0 (0)	58 (14)	196
4904	ECHO RESERVOIR	31 (8)	27 (7)	19 (5)	50 (13)	12 (3)	13 (3)	152
4905	LYNN RESERVOIR	8 (2)	23 (6)	58 (15)	8 (2)	62 (15)	4 (1)	163
4906	FISH LAKE	62 (16)	65 (16)	100 (26)	23 (6)	62 (15)	79 (20)	391
4907	HUNTINGTON NORTH RESERVO	77 (20)	65 (16)	69 (18)	92 (24)	96 (25)	69 (18)	468
4908	JOE'S VALLEY RESERVOIR	81 (21)	58 (15)	62 (16)	85 (22)	46 (12)	96 (25)	428
4909	MINERSVILLE RESERVOIR	0 (0)	44 (11)	27 (7)	12 (3)	85 (22)	0 (0)	168
4910	MOON LAKE	100 (26)	87 (19)	73 (19)	77 (20)	69 (18)	100 (26)	506
4911	NAVAJO LAKE	69 (18)	87 (19)	77 (20)	88 (23)	100 (26)	85 (22)	506
4912	NEWCASTLE RESERVOIR	23 (6)	87 (19)	46 (12)	27 (7)	19 (5)	27 (7)	229
4913	OTTER CREEK RESERVOIR	15 (4)	87 (19)	15 (4)	31 (8)	54 (14)	8 (2)	210
4914	PANGUITCH LAKE	12 (3)	65 (16)	50 (13)	4 (1)	8 (2)	23 (6)	162
4915	PELICAN LAKE	37 (9)	54 (14)	38 (9)	54 (14)	90 (23)	73 (19)	343
4916	PINEVIEW RESERVOIR	50 (13)	15 (4)	38 (10)	58 (15)	4 (1)	58 (14)	223
4917	PIUTE RESERVOIR	27 (7)	31 (8)	8 (2)	15 (4)	38 (10)	46 (12)	165
4918	PORCUPINE RESERVOIR	58 (15)	38 (10)	31 (8)	38 (10)	33 (8)	19 (5)	217
4919	PRUESS RESERVOIR (GARRIS	19 (5)	35 (9)	0 (0)	69 (18)	81 (21)	37 (9)	241
4920	SEVIER BRIDGE RESERVOIR	54 (14)	8 (2)	23 (6)	19 (5)	33 (8)	37 (9)	174
4921	STARVATION RESERVOIR	73 (19)	87 (19)	65 (17)	62 (16)	23 (6)	79 (20)	389
4922	STEINAKER RESERVOIR	85 (22)	87 (19)	88 (23)	96 (25)	27 (7)	65 (17)	448
4923	TROPIC RESERVOIR	65 (17)	50 (13)	54 (14)	46 (12)	90 (23)	58 (14)	363
4924	UTAH LAKE	4 (1)	12 (3)	4 (1)	0 (0)	42 (11)	13 (3)	75
4925	WILLARD BAY RESERVOIR	37 (9)	44 (11)	12 (3)	42 (11)	50 (13)	31 (8)	216
5605	FLAMING GORGE RESERVOIR	90 (23)	0 (0)	92 (24)	81 (21)	62 (15)	90 (23)	415

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	4901	BEAR LAKE	548
2	4911	NAVAJO LAKE	506
3	4910	MOON LAKE	506
4	4907	HUNTINGTON NORTH RESERVO	468
5	4922	STEINAKER RESERVOIR	448
6	4908	JOE'S VALLEY RESERVOIR	428
7	5605	FLAMING GORGE RESERVOIR	415
8	4902	LOWER BOWN'S RESERVOIR	406
9	4906	FISH LAKE	391
10	4921	STARVATION RESERVOIR	389
11	4923	TROPIC RESERVOIR	363
12	4915	PELICAN LAKE	343
13	0408	LAKE POWELL	311
14	4919	PRUESS RESERVOIR (GARRIS	241
15	4912	NEWCASTLE RESERVOIR	229
16	4916	PINEVIEW RESERVOIR	883
17	4918	PORCUPINE RESERVOIR	217
18	4925	WILLARD BAY RESERVOIR	216
19	4913	OTTER CREEK RESERVOIR	210
20	4903	DEER CREEK RESERVOIR	196
21	4920	SEVIER BRIDGE RESERVOIR	174
22	4909	MINERSVILLE RESERVOIR	168
23	4917	PIUTE RESERVOIR	165
24	4905	LYNN RESERVOIR	163
25	4914	PANQUITCH LAKE	162
26	4904	ECHO RESERVOIR	152
27	4924	UTAH LAKE	75

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

10/18/76

TRIBUTARY FLOW INFORMATION FOR UTAH

LAKE CODE 4921 STARVATION RES

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 2745.4

NORMALIZED FLOWS(CMS)

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
4921A1	2745.4	1.70	2.55	4.25	3.11	5.10	2.41	7.08	5.10	4.81	2.83	1.27	1.27	3.47
4921A2	2382.8	2.04	2.01	2.75	5.38	14.16	7.36	3.40	2.58	2.32	2.69	2.41	2.04	4.11
4921D1	0.0	2.832	2.549	2.832	3.398	0.566	0.850	0.0	0.0	0.0	1.133	3.398	3.115	1.714
4921ZZ	362.6	0.0	0.0	0.0	0.014	0.057	0.028	0.014	0.0	0.0	0.0	0.0	0.0	0.010
49212C	75.1	0.0	0.0	0.008	0.028	0.085	0.028	0.017	0.017	0.008	0.008	0.003	0.0	0.017

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 2745.4
SUM OF SUB-DRAINAGE AREAS = 2820.5

TOTAL FLOW IN = 70.12
TOTAL FLOW OUT = 41.48

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW
4921A1	11	74	0.283	10	0.283		
	12	74	0.283	14	0.283		
	1	75	0.283	12	0.283		
	2	75	0.283	8	0.283		
	3	75	1.076	9	0.283		
	4	75	5.380	6	2.379	18	9.911
	5	75	1.416	1	1.274	21	1.274
	6	75	6.230	7	6.513		
	7	75	5.663	14	5.097		
	8	75	4.814	16			
	9	75	2.605				
	10	75	2.115	10	2.067		
	11	74	1.792	14	1.784		
4921A2	12	74	1.699	12	1.699		
	1	75	1.727	8	1.699		
	2	75	2.495	9	2.350		
	3	75	2.294	6	2.039		
	4	75	9.345	1	2.379	18	10.477
	5	75	13.847	7	19.171	21	12.120
	6	75	4.106	14	3.115		
	7	75	2.622	16	2.350		
	8	75	1.866				
	9	75	2.087				
	10	75					

TRIBUTARY FLOW INFORMATION FOR UTAH 10/18/76

LAKE CODE 4921 STARVATION RES

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
4921D1	11	74	4.248	10	5.097				
	12	74	2.633	14	3.115				
	1	75	2.690	12	3.681				
	2	75	3.398	8	3.398				
	3	75	3.681	9	3.681				
	4	75	2.464	6	3.681				
	6	75	3.964	7	6.513	21	0.0		
	7	75	0.0	14	0.0				
	8	75	0.0	16	0.0				
	9	75	0.0						
	10	75	0.0						
4921ZZ	11	74	0.0						
	12	74	0.0						
	1	75	0.0						
	2	75	0.0						
	3	75	0.0						
	4	75	0.0						
	5	75	0.028						
	6	75	0.042						
	7	75	0.028						
	8	75	0.0						
	9	75	0.0						
	10	75	0.0						
49212C	11	74	0.0						
	12	74	0.0						
	1	75	0.0						
	2	75	0.0						
	3	75	0.003						
	4	75	0.028						
	5	75	0.057						
	6	75	0.085						
	7	75	0.028						
	8	75	0.017						
	9	75	0.008						
	10	75	0.008						

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/08/12

492101
40 10 16.0 110 29 50.0 3
STARVATION RESERVOIR
49013 UTAH

110691

11EPALES 2111202
0042 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/05/13	09 55	0000	6.7	9.7	47	503	8.60	298	0.030	0.500	0.030	0.013
	09 55	0005	6.7	9.4		504	8.60	302	0.030	0.400	0.020K	0.011
	09 55	0021	6.6			499	8.60	304	0.040	0.300	0.020K	0.004
	09 55	0037	6.6	9.8		505	8.60	330	0.030	0.400	0.020K	0.003
75/08/11	10 15	0000	15.2	7.0	120	636	9.10	256	0.020K	0.300	0.020K	0.007
	10 15	0005	15.7	7.0		587	9.10	306	0.020K	0.300	0.020K	0.004
	10 15	0025	15.4	7.4		640	9.10	288	0.020	0.200	0.020K	0.004
	10 15	0035	11.5	2.4		614	8.60	280	0.020	0.200	0.020K	0.003
	10 15	0060	8.4	3.8		621	8.85	304	0.040	0.300	0.020	0.009
75/09/24	09 00	0000	17.0	9.2	36	531	8.50	294	0.020K	0.200	0.020K	0.005
	09 00	0005	17.1	7.8		528	8.60	326	0.020K	0.200	0.020K	0.006
	09 00	0015	17.0	7.4		526	8.60	348	0.020K	0.300	0.020K	0.006
	09 00	0035	16.9	5.4		531	8.20	336	0.020K	0.300	0.040	0.009
	09 00	0056	15.1	2.8		552	8.60	324	0.020	0.300	0.020K	0.005

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/05/13	09 55	0000	0.025	5.8	
	09 55	0005	0.020		
	09 55	0021	0.022		
	09 55	0037	0.021		
75/08/11	10 15	0000	0.018	1.6	
	10 15	0005	0.016		
	10 15	0025	0.013		
	10 15	0035	0.018		
	10 15	0060	0.020		
75/09/24	09 00	0000	0.016	6.1	
	09 00	0005	0.015		
	09 00	0015	0.018		
	09 00	0035	0.024		
	09 00	0056	0.031		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 75/08/12

492102
40 11 04.0 110 29 03.0 3
STARVATION RESERVOIR
49013 UTAH

110691

11EPALES 2111202
0069 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/05/13	10 15	0000	6.5	9.8	96	491	8.60	330	0.030	0.500	0.020K	0.009
	10 15	0005	6.3	9.6		499	8.60	312	0.040	0.400	0.020	0.003
	10 15	0025	6.3	9.6		496	8.60	316	0.040	0.400	0.020	0.003
	10 15	0045	6.3	9.8		489	8.60	292	0.040	0.400	0.020	0.009
	10 15	0065	6.3	9.0		496	8.60	308	0.030	0.400	0.020	0.003
75/08/11	10 50	0000	16.2	8.0	180	622	9.10	278	0.020K	0.300	0.020K	0.004
	10 50	0005	16.2	7.4		620	9.10	274	0.020K	0.300	0.020K	0.004
	10 50	0020	16.2	7.6		617	9.10	290	0.030	0.400	0.020K	0.002
	10 50	0035	10.7	2.4		577	8.60	282	0.050	0.500	0.030	0.007
	10 50	0075	6.3	2.8		590	8.55	260	0.080	0.500	0.050	0.013
75/09/24	08 40	0000	17.2	8.4	60	522	8.60	308	0.020K	0.200	0.020K	0.003
	08 40	0005	17.2	6.8		524	8.60	324	0.020K	0.200	0.020K	0.004
	08 40	0015	17.1	7.2		522	8.60	316	0.020K	0.200	0.020K	0.004
	08 40	0035	16.9	6.6		525	8.40	316	0.020K	0.300	0.020K	0.008
	08 40	0056	16.0	4.4		538	8.60	276	0.020K	0.200	0.020K	0.004

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/05/13	10 15	0000	0.015	4.7	
	10 15	0005	0.016		
	10 15	0025	0.017		
	10 15	0045	0.021		
	10 15	0065	0.016		
75/08/11	10 50	0000	0.014	4.5	
	10 50	0005	0.014		
	10 50	0020	0.016		
	10 50	0035	0.021		
	10 50	0075	0.022		
75/09/24	08 40	0000	0.017	3.9	
	08 40	0005	0.013		
	08 40	0015	0.014		
	08 40	0035	0.017		
	08 40	0056	0.015		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/08/12

492103
40 11 02.0 110 26 42.0 3
STARVATION RESERVOIR
49013 UTAH

110691

11EPALES 2111202
0015 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/05/13	10 35	0000	7.7	10.4	114	500	8.60	266	0.030	0.400	0.020K	0.009
	10 35	0005	7.4	9.2		499	8.60	278	0.030	0.400	0.020K	0.004
	10 35	0011	7.2	9.6		499	8.60	266	0.030	0.200	0.020K	0.011
75/08/11	11 15	0000	16.7	7.6	204	616	8.45	200	0.020K	0.400	0.020K	0.003
	11 15	0005	16.7	7.4		622	8.70	196	0.020	0.500	0.020K	0.002
	11 15	0019	16.6	7.4		640	8.70	196	0.020	0.400	0.020K	0.002K
75/09/24	08 25	0000	17.2	7.8	108	517	8.60	280	0.020K	0.200K	0.020K	0.004
	08 25	0005	17.1	7.0		517	8.60	298	0.020K	0.200	0.020K	0.004
	08 25	0017	17.1	7.2		516	8.65	298	0.020K	0.200K	0.020K	0.004

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/05/13	10 35	0000	0.012	3.0	
	10 35	0005	0.021		
	10 35	0011	0.022		
75/08/11	11 15	0000	0.010	10.5	
	11 15	0005	0.010		
	11 15	0019	0.008		
75/09/24	08 25	0000	0.013	2.6	
	08 25	0005	0.012		
	08 25	0017	0.012		

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/08/12

492104
40 12 47.0 110 26 14.0 3
STARVATION RESERVOIR
49013 UTAH
110691

11EPALES 2111202
0046 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/05/13	10 55	0000	8.2	9.4	84	500	8.60	270	0.030	0.300	0.050	0.003
	10 55	0005	8.1	9.4		499	8.60	290	0.020	0.200K	0.020K	0.009
	10 55	0022	8.0	9.4		499	8.60	328	0.020	0.200K	0.020K	0.010
	10 55	0042	7.9	9.2		500	8.60	354	0.020	0.200K	0.020K	0.003
75/08/11	11 40	0000	17.8	7.6	144	630	8.80	192	0.020K	0.500	0.020K	0.002K
	11 40	0005	17.8	7.4		624	8.80	192	0.020	0.400	0.020K	0.002
	11 40	0020	17.5	2.0		618	8.50	191	0.030	0.200K	0.020K	0.002
	11 40	0046	9.1	1.8		575	8.20	258	0.040	0.200K	0.020K	0.002
75/09/24	08 10	0000	17.4	7.2	72	510	8.50	244	0.020K	0.200K	0.020K	0.004
	08 10	0005	17.4	7.2		513	8.65	286	0.020K	0.200	0.020K	0.006
	08 10	0018	17.4	7.0		513	8.60	284	0.020K	0.200K	0.020K	0.004
	08 10	0036	17.2	6.6		516	8.65	272	0.020K	0.200	0.020K	0.006

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/05/13	10 55	0000	0.015	2.6	
	10 55	0005	0.021		
	10 55	0022	0.016		
	10 55	0042	0.014		
75/08/11	11 40	0000	0.014	20.7	
	11 40	0005	0.016		
	11 40	0020	0.011		
	11 40	0046	0.016		
75/09/24	08 10	0000	0.013	2.1	
	08 10	0005	0.015		
	08 10	0018	0.012		
	08 10	0036	0.013		

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 76/08/12

4921A1
40 10 25.0 110 25 43.0 4
STRAWBERRY RIVER
49 7.5 DUCHESNE
O/STARVATION RESERVOIR 110691
RT 40 BRDG 1.5 MI BELO STARVATION DAM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/10	14	30	0.016	0.600	0.015	0.005K	0.010
74/12/14	15	30	0.040	1.100	0.025	0.005	0.020
75/01/12	17	15	0.064	0.200	0.005	0.005K	0.020
75/02/08	10	00	0.100	1.100	0.024	0.008K	0.010
75/03/09	17	00	0.048	0.800	0.032	0.008K	0.010K
75/04/06	10	00	0.050	0.850	0.050	0.005	0.010K
75/05/01	18	05	0.020	1.100	0.070	0.005K	0.060
75/05/18	08	30	0.020	0.250	0.010	0.010	0.030
75/06/07	09	30	0.015	0.300	0.055	0.005K	0.010
75/06/21	17	30	0.005	0.250	0.015	0.005K	0.020
75/07/14	18	30	0.040	1.800	0.010	0.005K	0.030
75/08/16	14	00	0.030	0.300	0.025	0.010	0.010
75/09/26	16	30	0.125	0.400	0.010	0.020	0.020

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/08/12

4921A2
40 09 15.0 110 30 50.0 4
STRAWBERRY RIVER
49 7.5 RABBIT GULCH
T/STARVATION RESERVOIR 110691
SEC RD BRDG 10 MI W OF DUCHESNE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/10	15 00		2.080	1.000	0.040	0.035	0.060
75/03/09	17 00		0.048	1.500	0.023	0.008K	0.530
75/04/06	09 30		0.005	1.350	0.130	0.040	0.190
75/05/01	18 20		0.005	1.130	0.135	0.030	0.135
75/05/18	09 00		0.290		0.050	0.040	
75/06/07	10 00		0.280	2.700	0.190	0.025	
75/06/21	15 00		0.005	0.850	0.010	0.005K	0.300
75/07/14	18 00		0.085	1.400	0.025	0.035	0.110
75/08/16	10 00		0.025	0.550	0.015	0.030	0.110
75/09/26	18 00		0.015	1.900	0.015	0.025	0.040

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/08/12

492101
40 14 30.0 110 24 40.0 4
DUCHESNE RIVER(KNIGHT DIVERSION)
49 7.5 DUCHESNE
T/STARVATION RESERVOIR 11069)
BNK .1 MI W SEC RD 5 MI N OF DUCHESNE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/11/10	13 30		0.280	0.300	0.015	0.005K	0.010
74/12/14	18 00		0.260	1.100	0.040	0.005K	0.010
75/02/08	09 45		0.192	0.500	0.016	0.008K	0.010K
75/03/09	10 30		0.048	0.900	0.060	0.068	0.100
75/04/06	09 00		0.040	1.250	0.025	0.020	0.020
75/05/01	17 45		0.015	1.000	0.160	0.005K	0.020
75/05/18	08 00		0.175	1.200	0.045	0.010	0.170
75/06/07	09 00		0.140	1.750	0.040	0.025	
75/06/21	17 00		0.135	0.350	0.010	0.010	0.050
75/07/14	19 00		0.055	1.350	0.007	0.010	0.090
75/08/16	11 30		0.045	0.150	0.005	0.005K	0.010K
75/09/26	16 00		0.065	0.700	0.015	0.005K	0.010K

K VALUE KNOWN TO BE
LESS THAN INDICATED